First studies on the habitats of *Galba truncatula* (Mollusca Gastropoda : Lymnaeidae), the snail host of *Fasciola hepatica*, and the dynamics of snail populations in Northeastern Algeria

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SUMMARY

Field investigations were carried out in 1999-2001 in four districts of Northeastern Algeria (regions of Constantine and Jijel) to find the habitats of the snail *Galba truncatula* (O.F. Müller, 1774) in areas grazed by local livestock, to determine their principal characteristics, and to follow up the dynamics of eight snail populations throughout the year. A total of 36 habitats were found in the 73 km^2 surveyed, along the banks of rivers, road ditches, or in swampy areas. Higher surfaces of habitats, higher numbers of snails, and lower snail densities were found in swampy areas. Two periods of egg-laying throughout the year were noted. The major period ranged from the end of October to December or January. The second period occurred in April-May (Jijel) or in May-June (Constantine). The occurrence of a two-annual generation pattern for *G. truncatula* and, consequently, the development of two *F. hepatica* (Linnaeus, 1758) cycles within snails over the year must be considered to control fasciolosis in Northeastern Algeria.

KEY-WORDS : Algeria - annual generations - *Galba truncatula* - habitats - Lymnaeidae - Mollusca - shell height.

RÉSUMÉ

Premières études sur les habitats de *Galba truncatula* (Mollusques Gastéropodes : Lymnaeidae), mollusque hôte de *Fasciola hepatica*, et la dynamique des populations dans le Nord-est algérien. Par A. MEKROUD, A. BENAKHA, C. BENLATRECHE, D. RONDELAUD et G. DREYFUSS.

Des investigations de terrain ont été réalisées en 1999-2001 dans quatre secteurs du nord-est algérien (régions de Constantine et de Jijel) pour trouver les habitats du mollusque *Galba truncatula* (O.F. Müller, 1774) dans les zones pâturées par le bétail, déterminer leurs principales caractéristiques et suivre la dynamique de huit populations au cours de l'année. Trente-six habitats au total ont été trouvés dans les 73 km^2 prospectés et se situent le long des berges de rivière, dans des fossés de route ou dans des zones marécageuses. Des valeurs plus élevées dans les prairies marécageuses ont été notées pour la superficie des gîtes à *G. truncatula* et le nombre total de mollusques alors que la densité des limnées y est plus faible que dans les deux autres types d'habitats. Deux périodes de pontes ont été notées au cours de l'année. La période principale s'étend de la fin octobre à décembre ou à janvier. La seconde se situe en avril-mai (Jijel) ou en mai-juin (Constantine). La présence d'un schéma à deux générations annuelles pour *G. truncatula* et, par suite, celle de deux cycles de *F. hepatica* (Linnaeus, 1758) chez la limnée au cours de l'année doivent être pris en considération pour contrôler la fasciolose dans l'Algérie du nord-est.

MOTS-CLÉS : Algérie - *Galba truncatula* - générations annuelles - habitat - hauteur de la coquille - Lymnaeidae - Mollusques.

Introduction

Fasciolosis due to *Fasciola hepatica* (Linnaeus, 1758) is well known in western Maghreb, as this parasitosis causes disease in man or grazing animals. Human infection with liver fluke is rare in Algeria [6, 7], whereas this disease is common in livestock. In the district of Jijel (Northeastern Algeria), the prevalence of natural infections with *F. hepatica* in cattle was 24.2 % in 1993-1994, whereas it was 8.5 % in the region of Constantine (unpublished data).

In Algeria, the snail *Galba truncatula* (O.F. Müller, 1774) is of major importance in transmitting fasciolosis [2]. Its presence was noted since 1920 (PALLARY [11], for example) and was confirmed in other subsequent reports [8, 10]. However, the distribution of snail habitats within the country was still little known. In northwestern Algeria, the snail was

living in wadis, springs, marshes, and irrigation canals [8], whereas in the other districts no information was available. As the aim of our work was to control fasciolosis and, particularly, the local populations of *G. truncatula* in Northeastern Algeria, preliminary studies on the habitats of this snail were necessary and the first objective of this study is to determine the characteristics of the lymnaeid habitats in the regions of this country.

In western Europe, most populations of *G. truncatula* show two generations successively replacing each other in the course of a year. A 3-generation pattern is also known for this species and occurs mainly during very wet years [12, 14]. Under favourable conditions, the mean growth of juvenile snails was 1 mm per week until the seventh week of life. After this date, the increase in the shell height is slower to reach a full size of 11 or 12 mm on sedimentary soils [9]. As the life-cycle of *G. truncatula* was not still studied in Northeastern Algeria, the second objective of this study was to determine how many generations the snail might develop throughout the year. To answer these questions, field investigations were carried out in the districts of Constantine and Jijel to find snail habitats in areas grazed by local livestock, determine their principal characteristics, and follow up the dynamics of snail populations throughout the year.

Materials and methods

The location of the four districts surveyed in Northeastern Algeria, the different types of sites investigated in each district, and their lengths are given in Figure 1 and Table I. The first two districts (Kaous, and Taher) were located in the region of Jijel (altitude, 30-50 m), whereas the other two (Djebel ouahch, and El Khroub) were situated in the region of Constantine (altitude, 750-900 m). These districts were chosen for snail studies, as natural infections of cattle with *F. hepatica* were detected in a previous study (unpublished data). The geographic distance between the region of Constantine and that of Jijel is 120 km.

The subsoil of these four districts is constituted with limestone. In the districts of Kaous and Taher, the climate is mediterranean, with a mean monthly temperature ranging from 9.5 to 26.6° C and a mean annual rainfall of 632 mm (Fig. 2a). In the other two, the climate is semiarid, with a mean monthly temperature ranging from 4.6 to 26.9° C and a mean annual rainfall of 373 mm (Fig. 2b). However, in the four districts, the rainy season mainly occurs during winter months and also in May (a mean of 95.3 mm of rainfall for this month in the region of Constantine and 84.4 mm in that of Jijel).

Three distinct operations were performed in these four districts. First, the habitats of *G. truncatula* were identified in November-December 1999 using the method reported by GOUMGHAR *et al.* [4] : the banks of rivers and road ditches were surveyed every 100 m along a total length of 30 km, whatever the type of sites studied. The same method was also used in 12 swampy areas. Secondly, the surface area of each snail location (including places trampled by livestock), the count of snails present in each location, and the calculation of the snail density per m^2 of habitat were determined in May 2000, as all habitats were partly submerged during this period. Finally, monthly investigations were performed from February 2000 to January 2001 (between day 15 and day 25 for each month) in eight banks of rivers (two per district), each inhabited by an abundant population of *G. truncatula*. In each habitat, three quadrats of 1 m^2 each were randomly selected for each date of collection to count snails, measure their shell heights using a calliper, and verify the presence or the absence of their egg-deposits. After each collection, the snails were put back in their habitat.

The variables studied in each habitat of *G. truncatula* were the surface of each snail location, the total number of snails within each habitat, and the snail density per m^2 of site. To calculate the values of the first variable, the general form of each habitat and its measurements were reported on a map before a subsequent cutout of the drawing obtained into geometrical figures and the determination of their individual surfaces. The dynamics of snail populations throughout the year was analyzed via the number of snails per m^2 of habitat, their mean shell height, and the percentage of young snails measuring 2.1 to 3 mm in height. This last category of snails was chosen for this study, as they were preadults. These three variables were chosen to identify the number of annual generations for *G. truncatula*, according to the method used by GOUMGHAR *et al*. [5] in central Morocco. Mean values and standard deviations were calculated from the individual values recorded for each variable, taking into account the geographical district and the date of snail collection. A two-way analysis of variance [13] was used to establish levels of significance.

Results

NUMBER AND CHARACTERISTICS OF SNAIL HABITATS

Seventeen habitats of *G. truncatula* (Table II) were found in the 40 km^2 surveyed in the region of Constantine (7 on river banks, 5 in road ditches, and the 5 others in swampy areas). In the 33 km^2 investigated in the region of Jijel, a total of 19 habitats was noted, with 6 located on river banks, 6 in road ditches, and the 9 others in swampy areas. All populations of *G. truncatula* were found to be isolated from each other with no overlap.

The characteristics of snail habitats are given in Table II. The type of habitat had a significant effect on these characteristics. The mean surfaces ($F_{2.33} = 23.31$, $P < 0.001$) and total numbers of snails ($F_{2.33} = 10.54$, $P < 0.001$) recorded in swampy areas were significantly higher, whereas snail densities noted in swampy areas were significantly lower ($F_{2.33} = 4.75$, $P < 0.05$). The type of district had only a significant effect on snail densities, with higher mean values in the districts of Jijel ($F_{3.32} = 6.68$, $P < 0.01$).

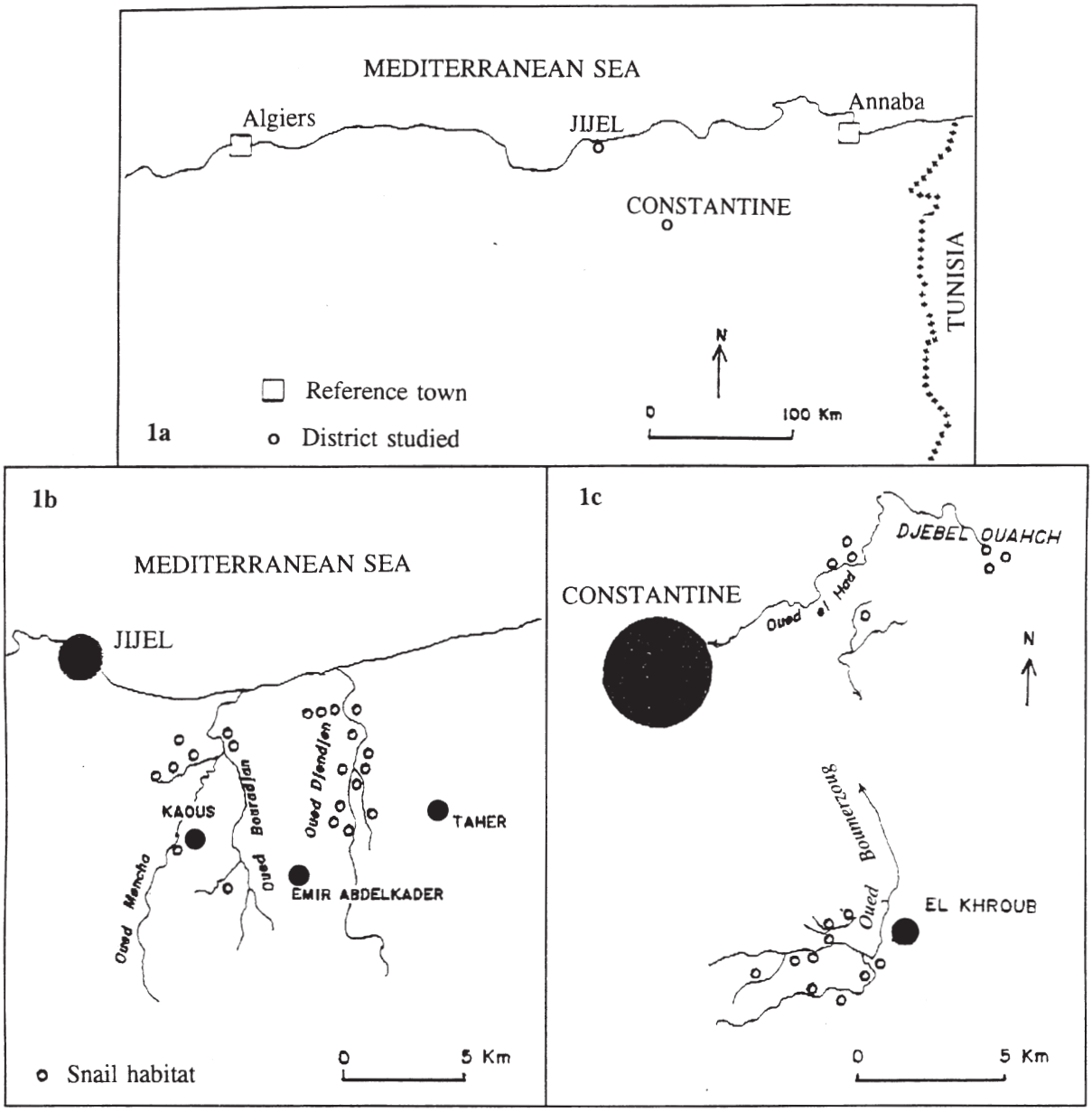

FIG. 1. — The geographic location of the two regions studied in Northeastern Algeria (1a) and that of snail habitats in the districts of Kaous and Taher (1b), or in those of Djebel ouahch and El Khroub (1c).

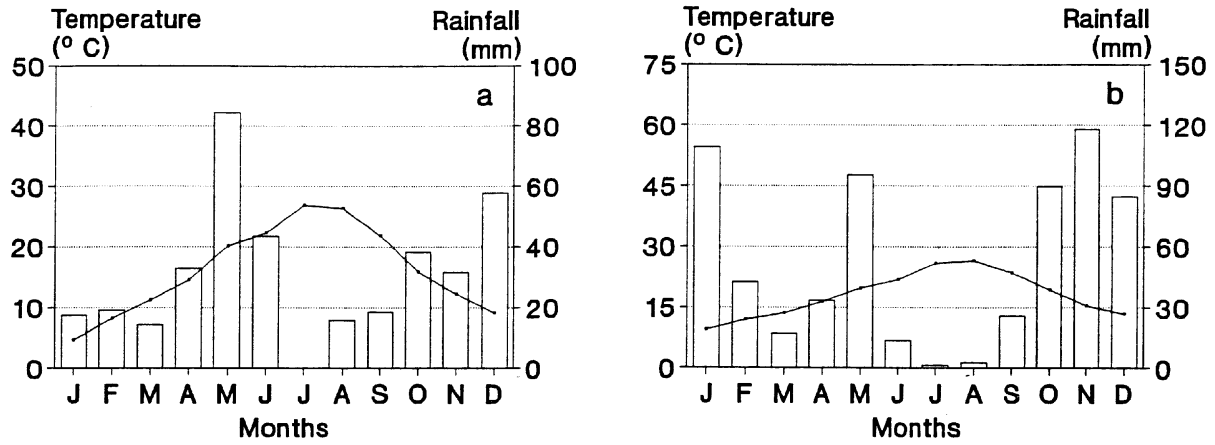

FIG. 2. — Meteorological diagrams showing seasonal changes of mean monthly temperature (broken line) and mean monthly rainfall (histograms) in the region of Constantine (2a) and that of Jijel (2b) throughout the year 2000. Months are indicated on each horizontal axis.

Region (Northeastern Algeria)*	District (and mean altitude in m)	Length (km) of areas prospected**		
		Banks of rivers (name of wadis)	Affluents and springs	Road ditches
Constantine	Djebel ouahch (900)	3 (Oued El had)	2	0
	El Khroub (750)	3 (Oued Boumerzoug)	7	2
Jijel	Kaous (50)	3 (Oueds Mencha and Bou radjah)	4	1
	Taher (20)	2 (Oued Djendjen)	4	1

* Other swampy areas surveyed : Djebel ouahch (3), El Khroub (2), Kaous (3), Taher (4).
** The wadis and road ditches were surveyed every 100 m in length.

TABLE I. — The sites surveyed in 1999-2000 in the regions of Constantine and Jijel (Northeast-ern Algeria).

In the districts of Djebel ouahch and El Khroub, thirteen habitats were colonized by *G. truncatula* only, while the 4 other sites were each inhabited by *G. truncatula* and *Physella acuta* (Draparnaud, 1805). In the districts of Kaous and Taher, the numbers of habitats were 12 and 7, respectively (data not shown). The comparison of mean values between the sites inhabited by *G. truncatula* only and those colonized by the two freshwater species did not demonstrate any significant differences, whatever the district and the variable studied.

DYNAMICS OF POPULATIONS THROUGHOUT THE YEAR

Figures 3, 4, and 5 show the fluctuations of three parameters in the fours sites studied from February 2000 to January 2001.

In the four populations from Djebel ouahch and El Khroub (region of Constantine), the numbers of *G. truncatula* showed the same fluctuations over time. The highest snail densities (Figs. 3a, 3b) were observed from December to March, whereas the lowest values were noted in June and September. In spite of this finding, two periods of egg-laying were noted in these sites. The first occurred in May and/or June, and was followed by a slight decrease in the mean shell heights of snails (Figs. 4a, 4b) ; the second was noted in November-December, with a more marked decrease in the mean shell heights. The percentages of 2.1-3 mm high snails (Figs. 5a, 5b) over the year confirmed these results. In May-June, the increases of these percentages were slight, whereas they were higher in November-December. This last finding indicated the overwintering generation of *G. truncatula* was more considerable than the spring-born generation.

In the four populations from Kaous and Taher (region of Jijel), two peaks in snail densities were observed. The first occurred in March (Fig. 3c) or April (Fig. 3d), whereas the second peak was noted in November or December, respectively. Two periods of egg-laying were also noted. The overwintering snails laid their eggs in April-May but the number of their progeny seemed low, as the mean shell heights of snails (Fig. 4c, 4d) did not show any clear decreases in the subsequent months. The second period was more variable and occurred from October to January (Kaous), or from October to December (Taher). This variability was also found in the shell heights, as the lowest values were noted in December (Fig. 4c) or in October (Fig. 4d). In the sites studied, the percentages of 2.1-3 mm high snails steadily decreased from February until July and only peaked in October (Fig. 5c, 5d).

District	Type of habitat* (and number per type)	Mean values ± S.D.		
		Surface area (m^2)	Total number of snails	Snail density per m^2 of habitat
Djebel ouahch	River banks (4)	5.8 ± 5.6	86.2 ± 52.7	14.3 ± 1.9
	Swampy areas (3)	16.9 ± 7.1	193.6 ± 97.7	11.5 ± 2.6
El Khroub	River banks (3)	8.3 ± 3.7	172.2 ± 157.7	20.2 ± 2.6
	Road ditches (5)	6.8 ± 2.7	113.9 ± 35.4	17.1 ± 5.8
	Swampy areas (2)	18.8 ± 8.7	220.7 ± 52.0	12.4 ± 2.8
Kaous	River banks (3)	7.0 ± 1.0	166.3 ± 79.1	23.1 ± 4.0
	Road ditches (2)	5.2 ± 2.7	130.7 ± 10.5	24.8 ± 1.1
	Swampy areas (3)	40.6 ± 15.0	715.1 ± 289.4	17.4 ± 3.5
Taher	River banks (3)	7.7 ± 2.2	189.6 ± 41.1	25.3 ± 2.0
	Road ditches (4)	5.0 ± 2.5	125.7 ± 66.8	25.1 ± 1.4
	Swampy areas (4)	24.5 ± 9.3	375.6 ± 82.6	17.3 ± 8.6

TABLE II. — The principal characteristics of *Galba truncatula* habitats in the regions of Constantine (Djebel ouahch, El khroub) and Jijel (Kaous, Taher), Northeastern Algeria.

Comparison of mean shell heights in March, April, and May did not demonstrate any significant variation between the eight populations studied. For each population of *G. truncatula* considered separately, there were no significant differences between the mean shell heights of overwintering snails noted in May-June and those of spring-born generation recorded in October-November.

Discussion

In the 73 km^2 surveyed, a total of 36 snail habitats were found along river banks, road ditches, and in marshes of Northeastern Algeria. The three types of habitats corresponded to those reported by MASSOT and SENOUCI-HORR [8] in the northwestern part of this country. However, the total number of sites was clearly higher in the northeastern part, as these last authors had only found 33 habitats in an area between Alger and the Algero-Moroccan frontier. This discrepancy might easily be explained by the technique of investigation used in this study (every 100 m) and demonstrated that snail habitats were more numerous in Algeria than previously believed. The other characteristics of *G. truncatula* habitats corresponded to those reported by GOUMGHAR *et al.* [4] in central Morocco, or by DREYFUSS *et al.* [3] and VAREILLE-MOREL *et al.* [16] in central France. However, two points warrant special comments. First, the higher areas colonized by *G. truncatula* in swampy areas and the higher numbers of snails indicated these sites constituted the best habitats for the development of snail populations. As the values recorded in the marshes of Jijel were significantly greater than those found in the districts of Djebel ouahch and El Khroub, the swampy areas of the former region seemed to offer more suitable conditions to the snails, probably because of milder climatic variations in the lowland region of Jijel. It would be of interest to determine the impact of such conditions on the prevalences of natural infections with *F. hepatica* in snails. Secondly, the absence of significant differences between the mean values recorded in the sites inhabited by *G. truncatula* only and those colonized by *G. truncatula* and *P. acuta* suggested the relationships between the two species in these last communities would be well balanced and that *P. acuta* would have lost its invasive character in these habitats, as this last species was known to colonize actively rivers on South Africa [1] or open drainage systems in central France [15].

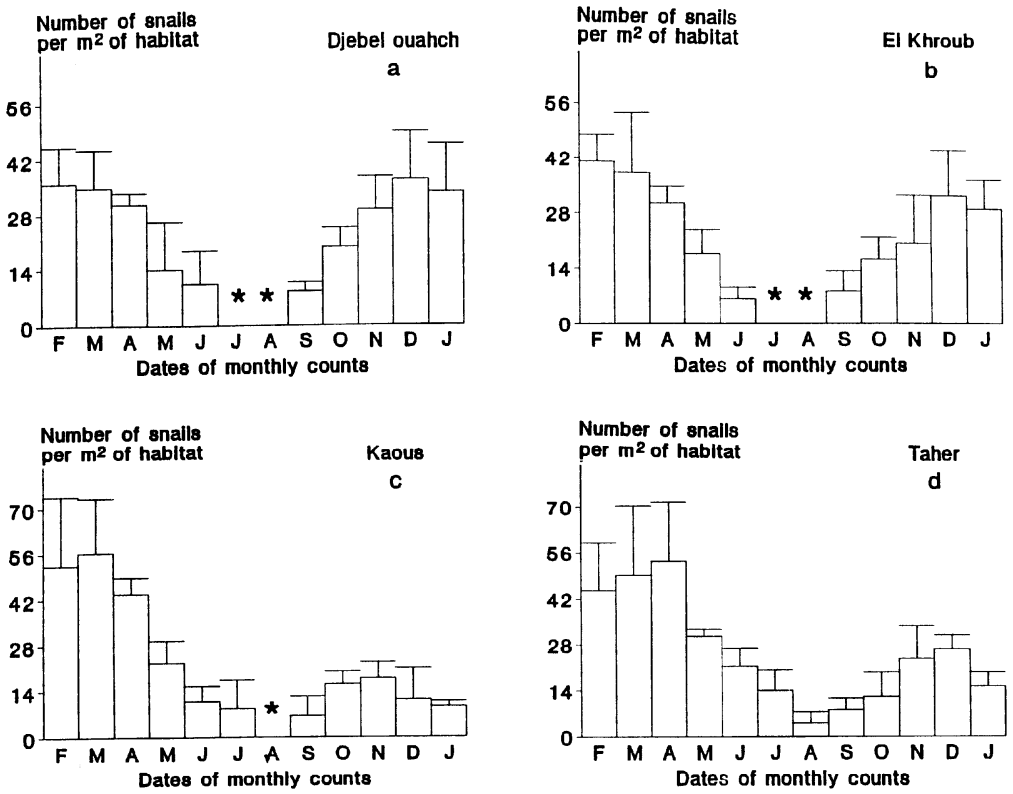

FIG.3. — The density of *Galba truncatula* per m^2 of habitat in the eight populations (2 per district) from Northeastern Algeria studied from February 2000 to January 2001. *, summer drying of habitats.

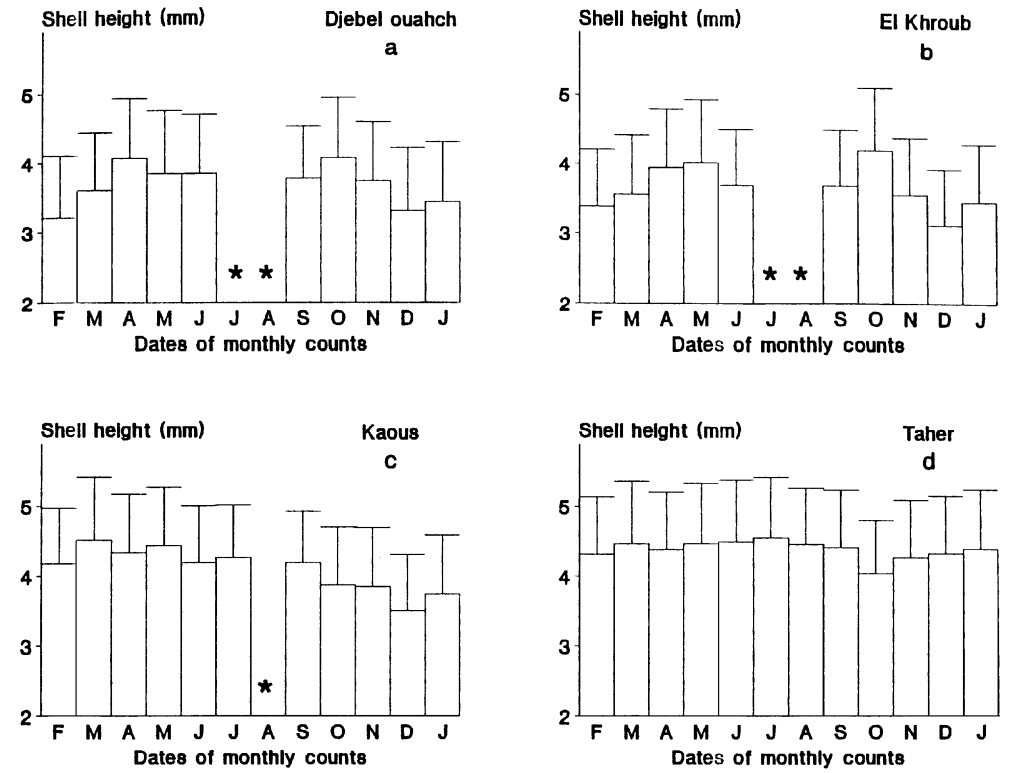

FIG.4. — The shell height of *Galba truncatula* in the eight populations (2 per district) from Northeastern Algeria studied from February 2000 to January 2001. Mean values are given with their standard deviations. *, summer drying of habitats.

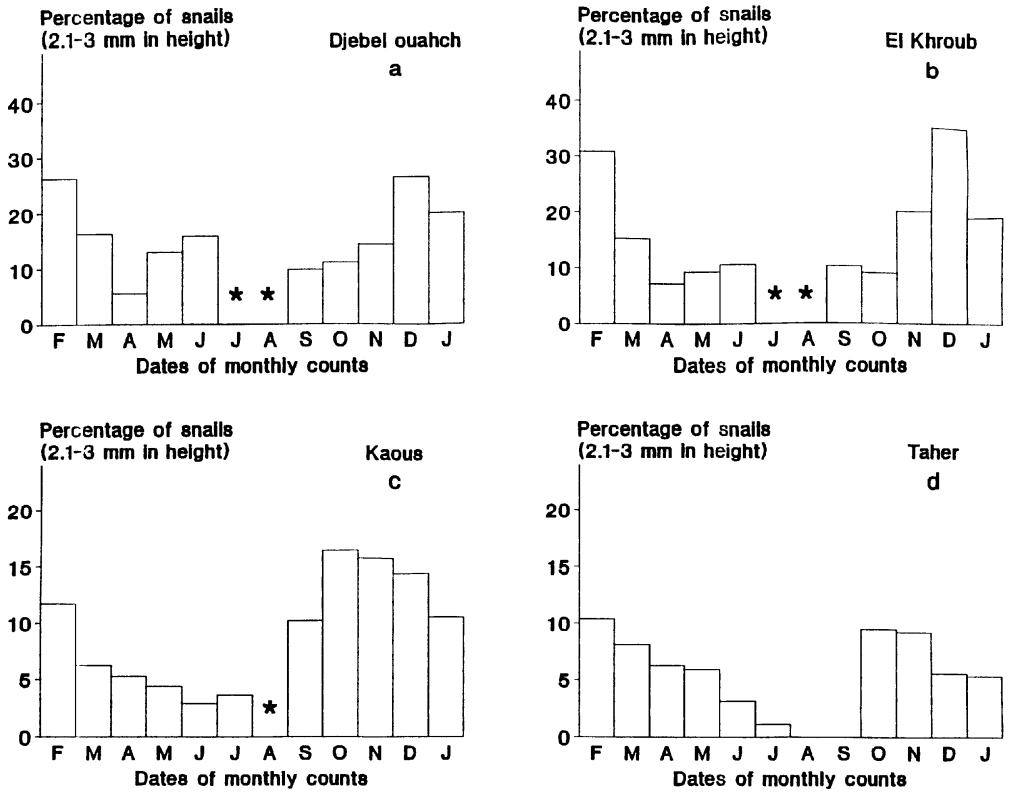

FIG.5. — The percentage of young *Galba truncatula* measuring 2.1 to 3 mm in height in the eight populations studied from February 2000 to January 2001. *, summer drying of habitats.

Despite some slight fluctuations in the dates of both egg-laying periods, the two-generation pattern per year found for *G. truncatula* in the regions of Constantine and Jijel verified the first observations that MASSOT and SENOUCI-HORR [8] had reported in northwestern Algeria. They also agreed with the observations that several authors [9, 12] had made in western Europe. Snails from the autumn-born generation can overwinter, contribute to the next year's breeding season in spring, and end their life in May or June before summer drying of habitats. On the other hand, the spring-born generation can aestivate and lay egg-deposits in autumn before subsequent death of snails at the end of the year. In spite of this similarity in these findings, two points found in this study warrant special comments. First, the longer durations of the main egg-laying period and the higher snail densities of overwintering snails found in the eight populations of *G. truncatula* (see Fig. 3) might be easily explained by the temperate climatic conditions which occurred in autumn and winter. Secondly, the deposits of eggs by overwintering snails in May-June and the subsequent growth of their progeny were disturbed by the onset of summer drying from June, so that many juvenile snails rapidly aestivated and continued their growth only during the postsummer re-submersion of habitats by water.

As *G. truncatula* acted as an intermediate host in the life-cycle of *F. hepatica*, the existence of a two-generation pattern for the lymnaeid species indicated that two successive parasitic cycles could develop within snails over the year. Further studies are necessary to determine the prevalences of natural infections in these populations of *G. truncatula* over the year and to verify if overwintering snails were the most infected with *F. hepatica* and might produce most cercariae in the field.

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